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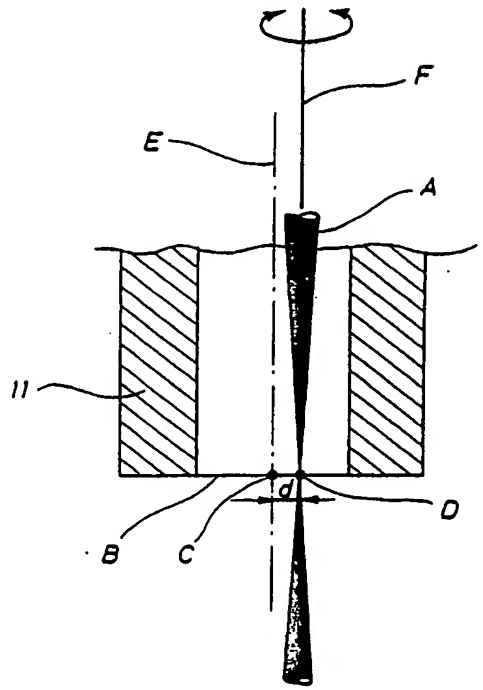
(54) Title: A NOZZLE FOR LASER PROCESSING

(57) Abstract

A nozzle for laser processing, such as a cutting, said processing allowing a laser beam (A) to be directed towards an article being processed, and whereby the laser beam is supported by a gas flow directed towards the article through the nozzle. According to the invention the nozzle (11) is able to maintain a displacement of the focusing point (D) of the laser beam relative to a centre of gas pressure (C) for the gas flow through the nozzle, whereby the laser beam (A) is displaced forwards in the processing direction relative to the centre of gas pressure (C). As a result the laser beam meets the article first and melts this portion of the article, said portion subsequently being blown away by the gas flow. In this manner the gas flow is efficiently ulitized because it does not meet the article until the material to be removed has melted and is thereby removable by blowing.



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Title: A nozzle for laser processing

Technical Field

The present invention relates to a nozzle for laser processing, such as a cutting, said processing allowing a laser beam to be directed towards an article being processed, and whereby the laser beam is supported by a gas flow directed towards the article through the nozzle.

Background Art

It is common knowledge to use a laser for cutting metal, as well as it is common knowledge to use a gas beam including for instance oxygen or a mixture gas together with the laser beam towards the processed area.

Description of the Invention

Under usual conditions a coaxially positioned laser beam is used, i.e. a laser beam situated in the axis (E) through the centre point (C) of the nozzle. In other words the laser beam is situated on the location having the highest gas pressure/gas flow. Furthermore the symmetrical positioning of the laser beam in the nozzle provides a uniform cutting quality irrespective of the cutting direction. A cut groove is obtained by a movement of the laser beam/nozzle relative to the material. The purpose of the supporting cutting gas is substantially to remove melt and vapours from the cut groove. The ability of the process to remove the waste material depends on the flow conditions in the nozzle and in the cut groove.

According to the invention the nozzle is able to maintain a displacement of the focusing point of the laser beam relative to a centre of gas pressure for the gas flow through the nozzle, whereby the laser beam is displaced

forwards in the processing direction relative to the centre of gas pressure. As a result the laser beam meets the article first and melts this portion of the article, said portion subsequently being blown away by the gas flow. In this manner the gas flow is efficiently utilized because it does not meet the article until the material to be removed has melted and is thereby removable by blowing.

The nozzle is preferably circular-cylindrical and able to maintain a predetermined excentric position of the laser beam in the nozzle. According to an alternative embodiment a circular-cylindrical nozzle is also used, but this nozzle is mounted with the laser beam in the centre while an excentrically located outlet nozzle opening is provided for the gas flow. According to a particular embodiment the nozzle may be radially displaceable relative to the laser beam. Within the scope of the invention the nozzle may, however, be of other shapes than the circular-cylindrical.

The laser beam is preferably spaced a distance d from the centre of gas pressure, wherey 0.01 D is smaller than the distance d in turn being smaller than D/2, D being the diameter of the nozzle. The distance d corresponds preferably to 0.25 times the diameter of the nozzle.

An external control is preferably provided, said control controlling the nozzle and/or the laser beam in response to the desired direction of processing. Such an external control is advantageously connectable to an existing control of cutting table and/or the laser head. According to a preferred embodiment the nozzle maintains a predetermined position of the laser beam in the nozzle relative to the direction of processing in such a manner that the centre of gas pressure and the laser beam are substantially always situated on the tangent of the direction of processing.

Brief Description of the Drawings

The invention will be described below with reference to the accompanying drawings, in which

Fig. 1 is a sectional view through the outer portion of a nozzle according to the invention,

Fig. 2 illustrates the movement of the nozzle of Fig. 1 during the alteration of a cutting direction,

Fig. 3 illustrates a second embodiment of a nozzle according to the invention,

Fig. 4 illustrates a third embodiment of a nozzle according to the invention,

Fig. 5 illustrates a still further embodiment of a nozzle according to the invention, and

Fig. 6 illustrates further examples of various nozzle openings.

Description of the Preferred Embodiments of the Invention

Fig. 1 illustrates the principles of the nozzle according to the invention. A laser beam A is focused through a nozzle opening. The nozzle opening is preferably circular-cylindrical but may have other shapes. A gas, such as oxygen or a mixture gas, is sent together with the laser beam A through the nozzle to remove the material being melted by the laser beam. The centre of gas pressure - i.e. the location having the highest dynamic gas pressure causing the highest flow velocity - is then situated in the centre of the nozzle at point C on the centre axis E. The focal point, i.e. focus D, of the laser beam is displaced relative to the centre axis F at the distance d

from point C.

Fig. 2 shows a cut groove 22 in an article. The arrow 24 indicates the cutting direction, and the arrow 25 indicates a new cutting direction. A nozzle 11 has been shown at four different positions. As it appears from the Figure the centre of gas pressure 30 is centrally located in the nozzle opening whereas the focal point 26 of the laser beam is displaced forwards in the cutting direction. During the first phase of the movement the nozzle is displaced in the cutting direction with the focal point of the laser beam in front in a rectilinear movement. When the point of discontinuity 32 has been reached, the rectilinear movement is stopped and the nozzle is rotated about the focal point of the laser beam, cf. the arrow 25 and the angle θ. Subsequently the rectilinear movement is continued in the new cutting direction 24'. As illustrated in Fig. 2 the focal point 26 of the laser beam is now situated in front of the centre of gas pressure 30 in the new cutting direction.

Fig. 3 illustrates an alternative embodiment. According to this embodiment the laser beam 10 is positioned in such a manner that the axis 20 of the laser beam coincides with the axis of the substantially cylindrical nozzle. In turn the nozzle opening 32 is excentrically situated. The nozzle of Fig. 3 can be used as illustrated in Fig. 2, said Figure illustrating the use of the nozzle of Fig. 1 with the exception that the focal point of the laser beam is centered in the nozzle and the nozzle opening. As a consequence the centre of gas pressure is displaced backwards relative to the cutting direction.

Fig. 4 shows a still further embodiment where the nozzle is a radially displaceable plate 34 comprising a nozzle opening 32. The feeding of gas to such a plate can, of course, be established in many ways and has not been shown.

Fig. 5 illustrates an embodiment comprising a fixed nozzle 34 and a centrally located nozzle opening 32 as well as a laser beam 10. The position of the focal point of this laser beam is determined by a movable lens system 36 or another type of movable optical instruments, such as a system of concave mirrors, optical units/plates or the like instruments. The invention may, of course, be varied in many ways, and the varous embodiments outlined can be combined. The nozzle and the nozzle opening need not necessarily be circular-cylindrical either but may as indicated in Fig. 6 have different shapes. As illustrated by the axial sectional view of Fig. 6 the nozzle may be cylindrical. Such a cylindrical nozzle may be circular-cylindrical of a cross section as outlined in Fig. 6d or elliptic-cylindrical of a cross section as outlined in Fig. 6e or of another advantageous shape like the one outlined in Fig. 6f. In order to ensure optimum flow conditions alternative embodiments of the nozzle may, however, also be considered, such as a conical nozzle, cf. Fig. 6b, or a double-frustoconical nozzle, cf. Fig. 6c. A transverse sectional view through these embodiments reveal many possibilities for the embodiment, such as for instance circular, elliptical or other more particular shapes. The essential feature to the invention is that the nozzle is shaped in such a manner that a well-defined centre of gas pressure is provided in the cutting plane and a laser beam is allowed to pass through the nozzle with a well-defined focal point also in the cutting plane, and furthermore in such a manner that a well-defined distance exists between the centre of gas pressure and the focal point. The nozzle must be mounted in such a manner that the focal point of the laser beam is always in front of the centre of gas pressure in the cutting direction. In this manner improved flow conditions are obtained through the nozzle and the cut groove, which implies that the deposition of burrs on the back of the cut is reduced significantly both when

oxygen and gas mixtures are employed. The use of particular gas mixtures as supporting cutting gas eliminates the deposition of the so-called "ball burrs" as said burrs are blown out of the cut groove before they harden, and consequently they do not have time to stick to the cutting edge.

The use of particular gas mixtures as supporting cutting gas ensures furthermore slagless cut surfaces when cutting in stainless steel.

Claims:

1. A nozzle for laser processing, such as a cutting, said processing allowing a laser beam to be directed towards an article being processed, and whereby the laser beam is supported by a gas flow directed towards the article through the nozzle, characterised by the nozzle (11) being able to maintain a displacement of the focusing point (D) of the laser beam relative to a centre of gas pressure (C) for the gas flow through the nozzle, whereby the laser beam (A) is displaced forwards in the processing direction relative to the centre of gas pressure (C).

2. A nozzle as claimed in claim 1, characterised by the nozzle being circular-cylindrical and able to maintain a predetermined excentric position of the laser beam (A) in the nozzle (11).

3. A nozzle as claimed in claim 1, characterised by the nozzle (11) being circular-cylindrical and provided with an excentrically located outlet opening (32) for the gas flow.

4. A nozzle as claimed in claim 1, characterised by the nozzle (34) being radially displaceable relative to the laser beam (10).

5. A nozzle as claimed in claim 2, characterised by the laser beam being spaced (d) from the centre, where $0.01\ D < d < D/2$, (D) being the diameter of the nozzle and (d) preferably corresponding to 0.25 times D.

6. A nozzle as claimed in one or more of the preceding claims, characterised by an external control being provided, said control controlling the nozzle and/or the laser beam in response to the desired direction of

processing.

7. A nozzle as claimed in claim 6, characterised by the external control being connectable to an existing control of cutting table and/or laser head.

8. A nozzle as claimed in one or more of the preceding claims, characterised by the nozzle being able to maintain a predetermined position of the laser beam in the nozzle relative to the direction of processing in such a manner that the maximum gas pressure flow and the laser beam are always positioned on the tangent of the direction of processing.

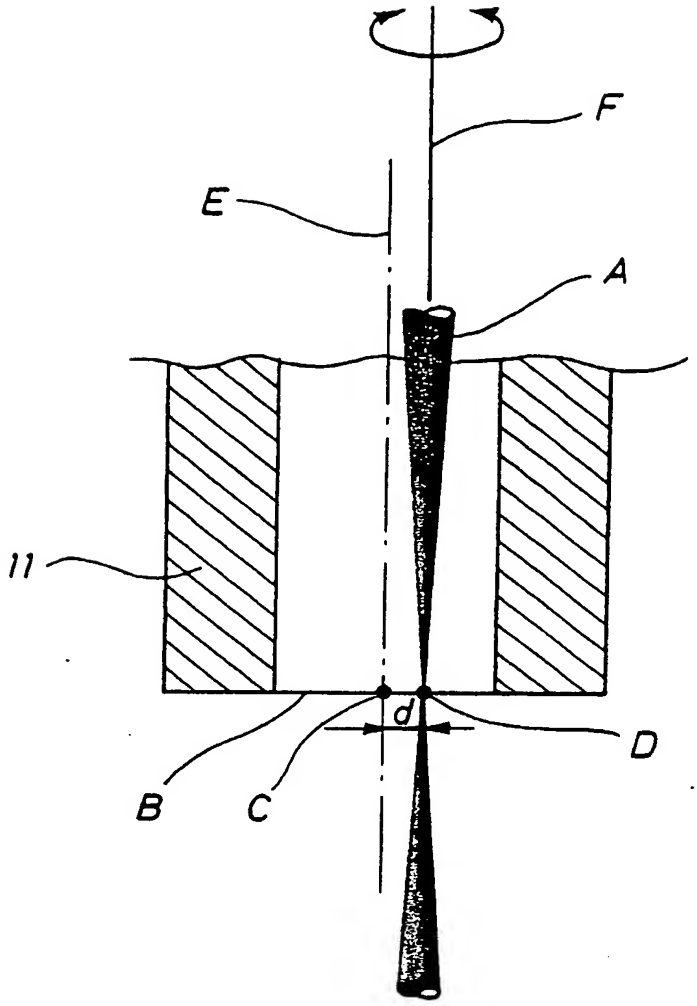

Fig. 1

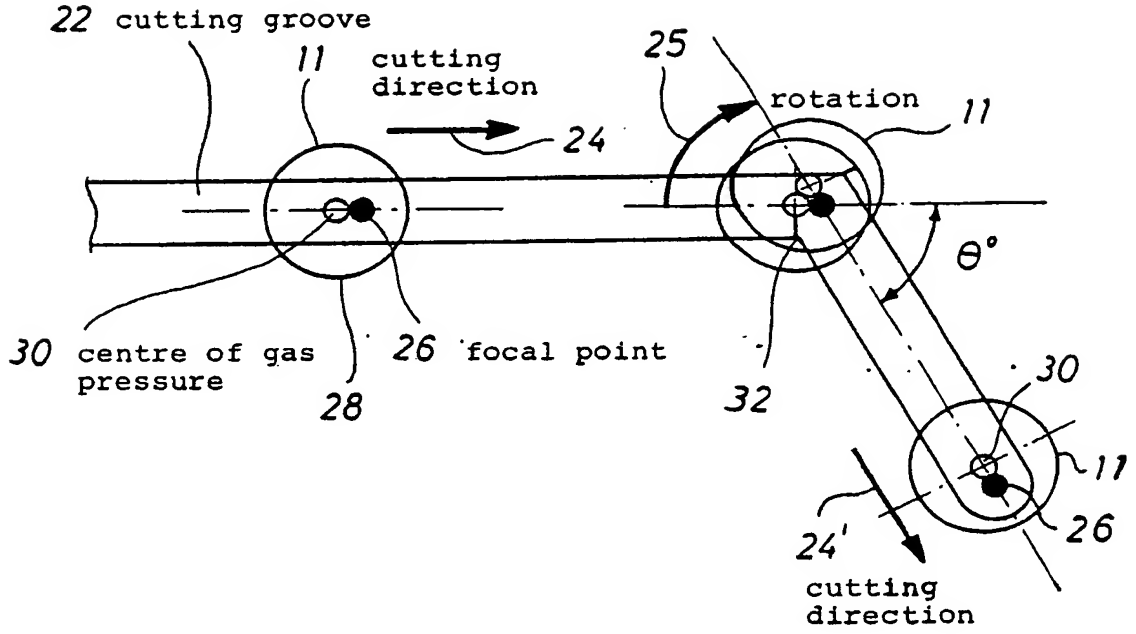
22 cutting groove
11
cutting direction
24
25
rotation
11
θ°
30 centre of gas pressure
28
26 focal point
32
30
11
26
24'
cutting direction

Fig.2

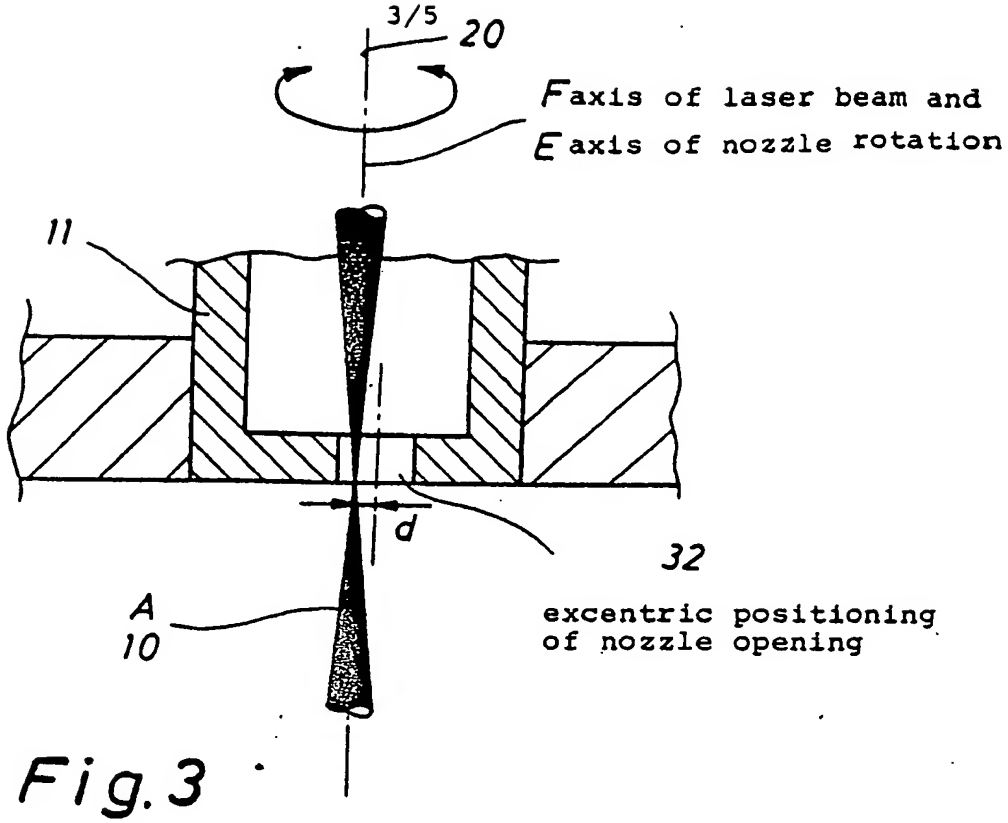
20
F axis of laser beam and
E axis of nozzle rotation
11
d
32
A
10
excentric positioning
of nozzle opening

Fig.3

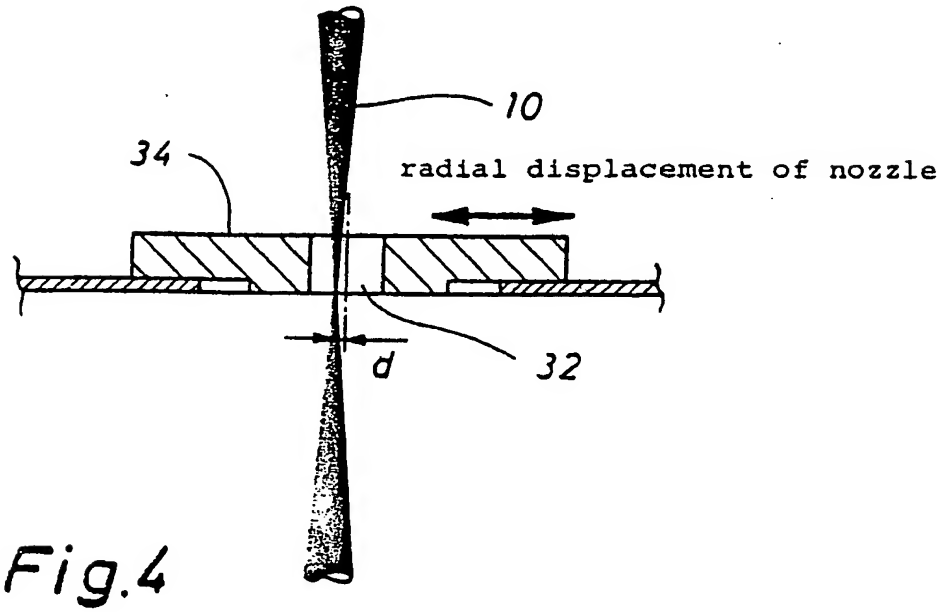
10
34
radial displacement of nozzle
d
32

Fig.4

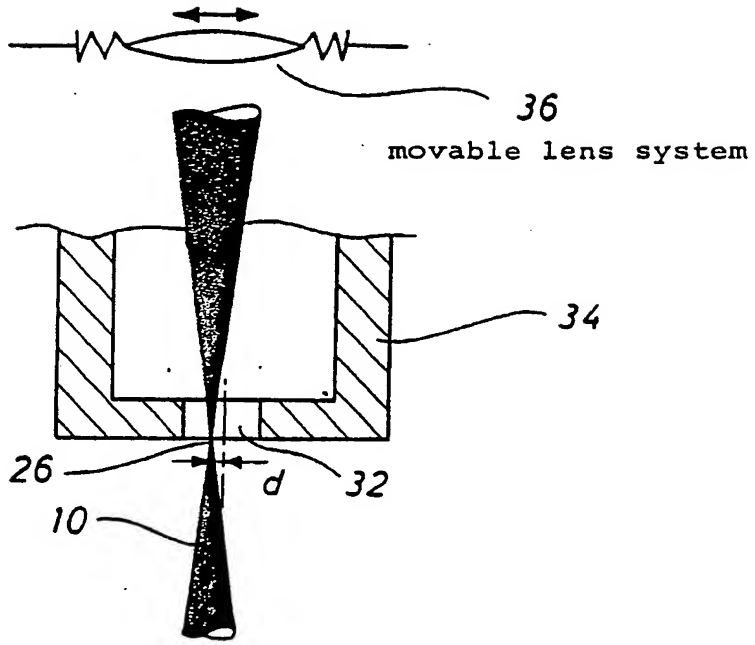

Fig.5

embodiments of nozzle opening

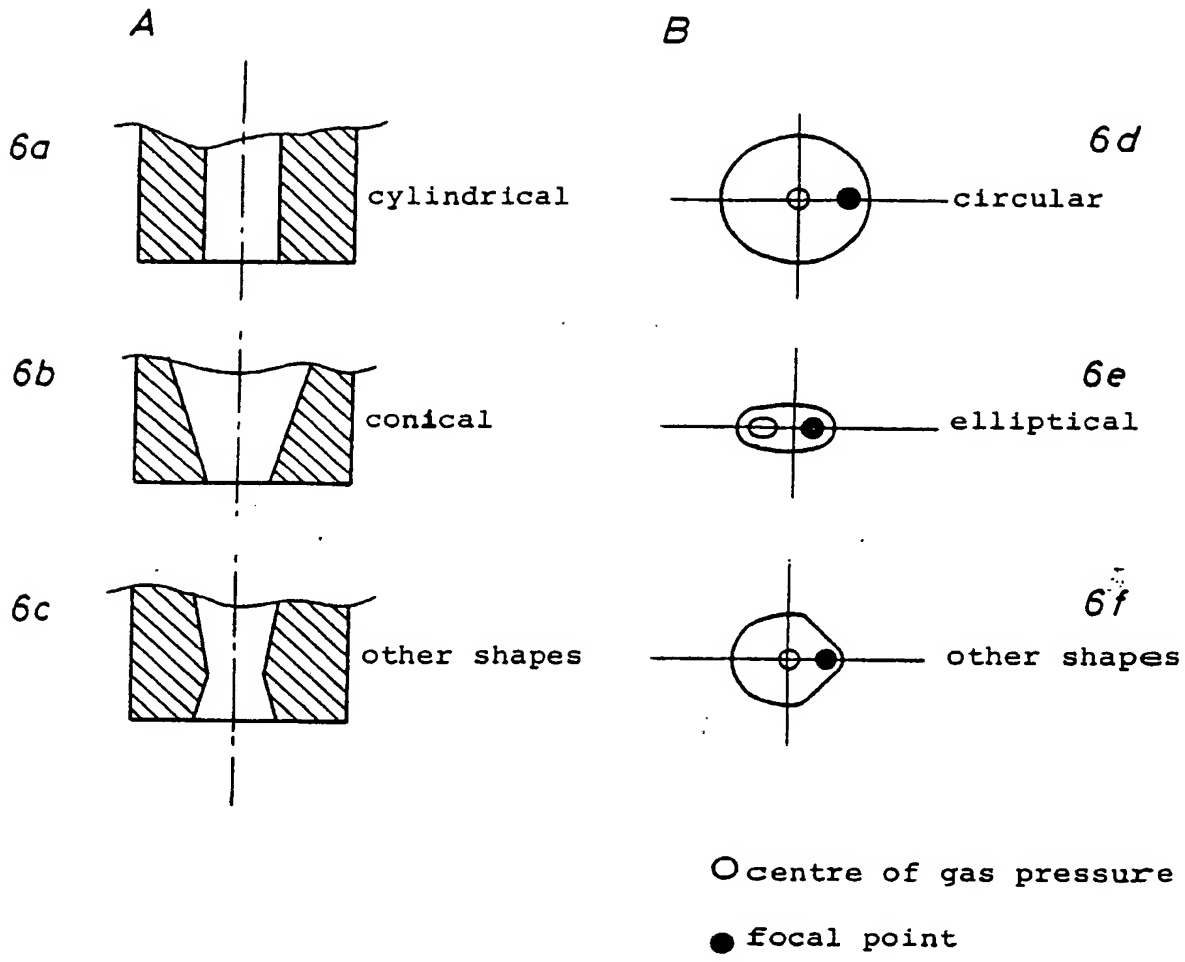

Fig.6

INTERNATIONAL SEARCH REPORT

International Application No PCT/DK87/00103

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

B 23 K 26/14 4

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC 4	B 23 K 26/00-/18, 27/00
Nat Cl	21h:30/02
US Cl	219: 121L, 121LC-121LJ, 121LN, 121LP, 121LU, 121FS, 121LM

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	Patent Abstract of Japan, abstract of JP 55-70492 (KAWASAKI...) 27 May 1980	1
A	DE, C2, 3 008 176 (CROSFIELD...) 11 September 1980	1
A	DE, B2, 1 690 637 (NATIONAL...) 30 March 1972	1, 2, 5
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IV. CERTIFICATION

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